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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—CIRCULAR 86.

A. C. TRUE, Director.

A PRELIMINARY REPORT

ON THE

ST. FRANCIS VALLEY DRAINAGE PROJECT IN NORTHEASTERN ARKANSAS.

PREPARED BY

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UNDER THE DIRECTION OF
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., August 5, 1909.

Sir: I have the honor to transmit herewith a preliminary report, accompanied by three maps, upon the drainage of a part of the lands in the St. Francis Basin, situated in northeastern Arkansas, prepared by Drainage Investigations of this Office.

For several years past there has been a movement on the part of the owners toward the reclamation of these fertile lands for agriculture, which naturally follows the removal of the merchantable timber with which the lands were originally covered. The low level of the land with respect to the Mississippi River and the vast area of the valley, which lies in both Missouri and Arkansas, present conditions which require a well-considered and comprehensive plan of reclamation upon which all property interests concerned will unite if the work required is to be accomplished.

A preliminary plan which is based upon careful surveys made by the engineers connected with Drainage Investigations of this Office is here presented. Since the area of land directly concerned with the plan is more than one million acres, it is desirable that the report be made available for general distribution. I therefore recommend that it be printed as a circular.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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A PRELIMINARY REPORT ON THE ST. FRANCIS VALLEY DRAINAGE PROJECT.

STATEMENT OF THE SITUATION.

The Office of Drainage Investigations of the U. S. Department of Agriculture in cooperation with the St. Francis Valley Drainage Investigation Association in 1908 and 1909 made a survey of the part of the St. Francis Valley lying in Mississippi, Craighead, and Poinsett counties, Ark., for the purpose of developing a plan for the systematic drainage of this area. The data secured by the survey have been arranged in proper form and a comprehensive plan is being prepared.

In order that those interested in this project may become familiar with the progress of the work, it has been decided to give at this time a brief preliminary statement of the general plan. As many of the details have not been fully worked out, the completed report will indicate a number of variations from the plan here outlined. A discussion of the reasons for arriving at the conclusions herein given will not appear in this brief statement, except in a general way.

THE PLAN PROPOSED.

The plan as a whole must include:

(1) Provision for carrying through this district the water discharged from more than 4,000 square miles in Missouri and from Clay and Greene counties in Arkansas, 1,500 square miles of which are hilly and mountainous territory, having the characteristic flood discharges of such regions. (Fig. 1.)

(2) Provision for main drainage channels to carry the drainage water from more than 1,500 square miles within the district, including the very large run-off from Crowley's ridge on the west.

(3) Provision for a complete system of detail drainage.

(4) Adjustment of the plans to the possible requirements of navigation, and to the conservation of soil moisture.

The proposed reclamation works may be outlined briefly as follows: A floodway between dikes to carry the water of the St. Francis River is planned to extend from the north line of Craighead County southerly along St. Francis Lake to its south end; thence southwesterly to Big Bay and down Big Bay to the enlarged channel near its mouth. A branch floodway similarly constructed to carry the waters of Little River is planned to begin at the State line and to extend southerly along Big Lake, and thence in a general southwesterly direction to the St. Francis floodway. The beds of St. Francis Lake and Big Lake will form regulating reservoirs, making possible the use of much smaller floodways than would otherwise be practical. In excavating earth for building the floodway levees, large ditches will be constructed outside the floodways, which will be used to their full capacity for carrying the drainage water from the adjacent land. The channels of St. Francis and Tyronza rivers and Little River, being thus relieved of the flood waters from Missouri, will be improved sufficiently to carry the remainder of the waters of the district. A system of lateral ditches averaging 1 mile apart will furnish thorough drainage for practically every part of the area. On the east and west margins of the valley surveys were not made in sufficient detail to warrant exact locations of lateral drains. The locations shown on the accompanying map of this part of the district indicate the general plan of detail drains and furnish a basis for estimating their cost.

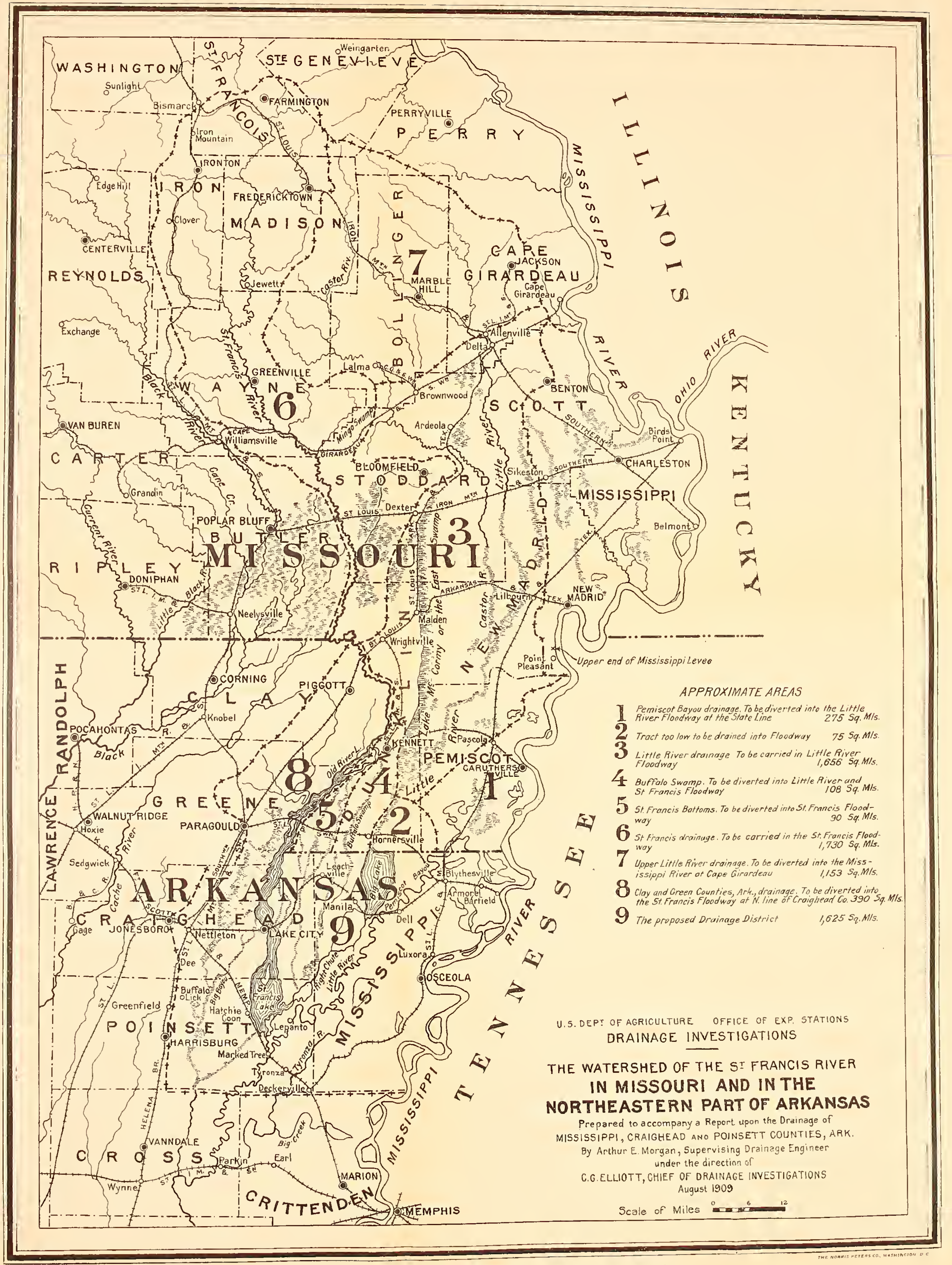
GENERAL DISCUSSION OF THE PROPOSED PLAN.

There are four methods which may be suggested for disposing of the waters of the St. Francis and Little rivers entering the district from the north.

First, the diversion of the hill waters of Little River into the Mississippi River at Cape Girardeau, the practicability of which has been fully determined, and has been incorporated in the plans of the Little River drainage district of Missouri. In all the plans herein considered it has been assumed that this diversion will be made. Should it not be made the width of projected floodways would need to be increased, involving an additional expense for condemning and clearing a wider right of way.

Second, the diversion of the waters of the St. Francis River in Missouri into the Black River and thence into White River. This would only transfer the problem from one locality to another, and would be difficult of accomplishment in the face of opposition which would develop along White and Black rivers. It, therefore, does not merit further consideration.

Third, the method toward which all previous efforts to improve conditions have been directed contemplates the improvement of the existing channels in such a manner as to give them sufficient capacity for carrying flood waters. In the light of the survey just completed, this plan is wholly impracticable, and would cost more than all the



APPROXIMATE AREAS

1	*Pemiscot Bayou drainage. To be diverted into the Little River Floodway at the State Line*	*275 Sq. Mls.*
2	*Tract too low to be drained into Floodway*	*75 Sq. Mls.*
3	*Little River drainage To be carried in Little River Floodway*	*1,656 Sq. Mls.*
4	*Buffalo Swamp. To be diverted into Little River and St Francis Floodway*	*108 Sq. Mls.*
5	*St. Francis Bottoms. To be diverted into St. Francis Floodway*	*90 Sq. Mls.*
6	*St Francis drainage. To be carried in the St. Francis Floodway*	*1,730 Sq. Mls.*
7	*Upper Little River drainage. To be diverted into the Mississippi River at Cape Girardeau*	*1,153 Sq. Mls.*
8	*Clay and Green Counties, Ark., drainage. To be diverted into the St. Francis Floodway at N. line of Craighead Co.*	*390 Sq. Mls.*
9	*The proposed Drainage District*	*1,625 Sq. Mls.*

U.S. DEPT OF AGRICULTURE OFFICE OF EXP. STATIONS
DRAINAGE INVESTIGATIONS

THE WATERSHED OF THE ST FRANCIS RIVER
IN MISSOURI AND IN THE
NORTHEASTERN PART OF ARKANSAS
Prepared to accompany a Report upon the Drainage of
MISSISSIPPI, CRAIGHEAD AND POINSETT COUNTIES, ARK.
By Arthur E. Morgan, Supervising Drainage Engineer
under the direction of
C.G. ELLIOTT, CHIEF OF DRAINAGE INVESTIGATIONS
August 1909

Scale of Miles 0 6 12

THE NORRIS PETERS CO., WASHINGTON, D.C.

FIG. 1.—The Watershed of the St. Francis River in Missouri and in the Northeastern Part of Arkansas.

THE NORRIS PETERS CO., WASHINGTON, D C

land in the proposed district is worth. There are several reasons why its impracticability has not been realized. It has been supposed that the flood discharge of the St. Francis River per unit of time after improvement would be about the same as at present, whereas it would be very much greater, for at present a great volume of the flood water of the streams of the valley flows into the lowlands of Missouri and Arkansas, which serve as storage reservoirs, allowing it to pass off very gradually. With the improvement of these streams and the confinement of their waters to narrow channels, run-off conditions would be so changed as to set at naught all estimates based on their present flow. At present the flood discharge of these streams occurs when the lowlands are overflowed and when the water over the land is in some parts of the district 8 feet higher than it must be when the land is in good condition for cultivation. The capacity of the beds of these streams below the line at which the water must be carried are so small as to be wholly insufficient for carrying even the local drainage water of the spring months. In fact, the bottom of the Left-Hand Chute of Little River is so nearly at the same elevation as the adjoining land that it is only with difficulty that any important use can be made of this apparently large and commodious channel. It would be far less expensive in many cases to dig entirely new channels to carry the flood waters than to improve those already in existence sufficiently to serve the purpose required.

Fourth, and the method recommended in this report, is the construction of floodways between levees, carrying the St. Francis and Little River waters above the surface of the ground, and for the most part outside of the channels they now occupy, leaving the latter to assist in carrying the local drainage water of the district. The cost of a wholly adequate system of floodways would be not more than about 10 per cent of the cost of improving the natural channels sufficiently to accomplish the same purpose, while at the same time with this method the natural channels would be preserved for other uses. The leveeing of the present channels of Little River and of the St. Francis River is not to be desired, because the banks of these streams are about 10 feet higher than the land on which the floodways are located. In some cases the ground surface along the floodways is lower than the beds of these streams. The water level between the dikes of the Little River floodway will be lower at flood stage than the present high-water level in either chute of that stream.

THE FLOODWAYS.

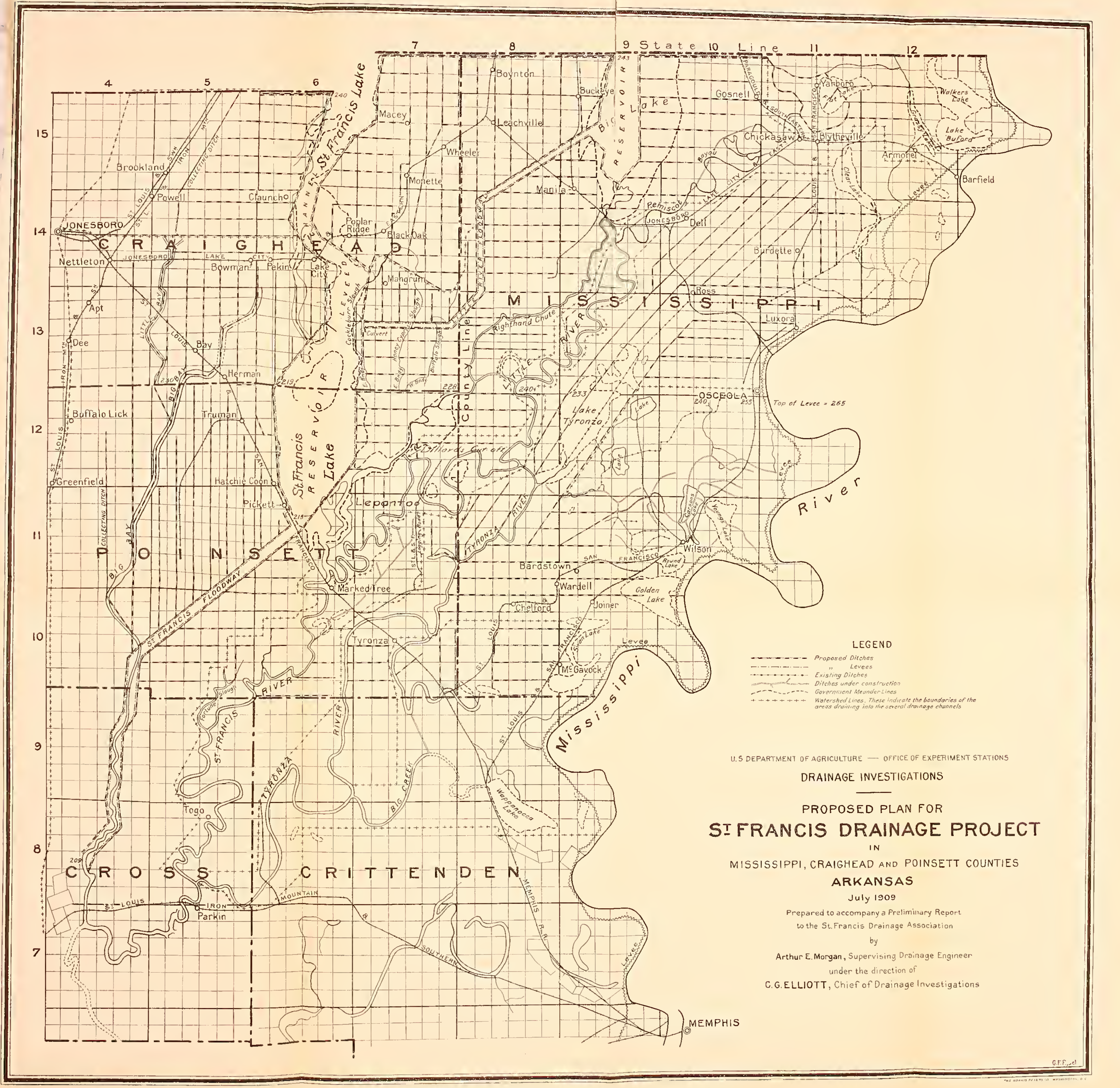
Beginning at the State line on the east and at the north line of Craighead County on the west, levees are planned on each side of St. Francis Lake to confine the waters of this river within the lake bed. Ditches will be constructed east and west along the north boundary of the district to collect all waters coming from the north and to lead them into the floodway. The waste banks will be deposited on the south sides of these ditches, forming levees to protect the lands of the district from overflow around the upper end of the floodway levees. (Fig. 2.)

For 18 miles south of the State line the flow of the river through the lake bed will not be impeded in any way, neither will its surface be raised except by a comparatively small amount of water which is collected along the State line and turned into it. For the lower 12 or 14 miles the lake bed will act as a storage reservoir, moderating through the lower floodway the flow resulting from storms in the mountainous region of the Upper St. Francis River. By the use of this reservoir the lower floodway may be made about half the width that otherwise would be required. The lands of the St. Francis Lake bed, included in this reservoir and upper floodway, are for the most part either in the permanent lake bed or so low as to be reclaimed only with great difficulty. As the larger part is unsurveyed Government land and lake bed, the cost of securing a right of way for the floodway should not be excessive.

From the lower end of St. Francis Lake the floodway is planned to extend southwesterly to Big Bay and down that stream to its enlargement a few miles above its mouth. The floodway will be 2,200 feet wide, carrying water 12 feet deep in extreme flood, which will have a surface slope of about 4 inches to the mile. Ditches outside the floodway will be formed by the excavation made by building the levees, and these will be employed to carry the local drainage water of the district.

A branch floodway similarly constructed is planned to begin at the State line and extend southerly along Big Lake and thence southwesterly to its junction with the St. Francis floodway. (Fig. 2.) A part of the bed of Big Lake will be used as a reservoir, but this area will include little land ever claimed as private property.

West of St. Francis Lake, in the north part of Craighead County, a considerable area of land within the district will be drained into the floodway. This will be done by digging a ditch outside the floodway levee and preventing it from overflowing by a secondary levee until its water can be brought to the same elevation as that inside the floodway; the inside levee will then be discontinued and the water discharged into the floodway, where it can be carried almost without additional cost. By this plan the cost will be perhaps $200,000 less than if ditches were constructed to carry this water below the ground surface the entire length of the district. In the same manner the drainage of the area between the St. Francis



U.S DEPARTMENT OF AGRICULTURE — OFFICE OF EXPERIMENT STATIONS

DRAINAGE INVESTIGATIONS

PROPOSED PLAN FOR
ST. FRANCIS DRAINAGE PROJECT
IN
MISSISSIPPI, CRAIGHEAD AND POINSETT COUNTIES
ARKANSAS
July 1909
Prepared to accompany a Preliminary Report
to the St. Francis Drainage Association
by
Arthur E. Morgan, Supervising Drainage Engineer
under the direction of
C. G. ELLIOTT, Chief of Drainage Investigations

FIG. 2.—Proposed Plan for St. Francis Drainage Project in Mississippi, Craighead and Poinsett Counties, Arkansas.

and Little River floodways is discharged into the St. Francis floodway, except that of a few square miles just above the junction, which must be carried under the Little River floodway by means of an underground conduit. The northeast corner of Mississippi County also can be drained effectively into the Little River floodway. While the cost of local drainage in doing so may perhaps exceed the cost of draining toward the south, the total saving, due to the relief from carrying this water below ground level for the entire length of the district, will amount to perhaps $150,000.

A ditch running east and west along the State line will divert all the remaining water from Missouri into the two floodways except that from perhaps a hundred square miles near Big Lake, which must be carried underneath these ditches and their adjoining levees and discharged into the ditches outside the floodways. By this plan Missouri land will not be damaged in any way but, on the contrary, will be benefited by the Arkansas improvement. If at any time it is desired to levee the St. Francis River in Dunklin County, Mo., and in Greene County, Ark., this work can be connected to the St. Francis floodway by constructing levees for a few miles inside the levees planned on this project, with ditches between to carry the drainage water from near-by land downstream to a point where it can be discharged into the floodway without any ill effects resulting from backwater. This is the same method as that used for diverting the drainage water of the upper part of the proposed district into the floodway.

MAIN CHANNELS FOR CARRYING THE WATERS OF THE DISTRICT.

The drainage waters of the district which are not carried into the floodways will be removed by the channels of Tyronza River, the two chutes of Little River, and the St. Francis River, and by the large ditches outside the floodways. Of the drainage waters of the district and the small amount which must enter it from Missouri outside the floodways, approximately a third will be carried in the improved natural channels, about a third in the ditches outside the floodways, and the remainder by the floodways.

In providing for the distribution of drainage water between the natural channels, it is found that Tyronza River, because of its straighter course and its location on lower ground, can be improved at much less expense than Little River, and for this reason it is planned to carry about twice as much water in the former stream as in the latter.

In passing along the Left-Hand Chute of Little River during high water one receives the impression that this is an important stream with large carrying capacity; yet, as a matter of fact, it lies on such high ground as to be of little use as a channel of the drainage system. Along its upper course the bottom of the channel is but 2 or 3 feet lower than land lying several miles to the north which is to be drained, and is at about the same elevation as land lying a few miles to the east, while its course is very crooked. It was decided, therefore, to make no improvement whatever of this channel, allowing the stream to carry as much as it will in its present condition, for it is found by computation that a given amount of excavation will accomplish far greater results in the improvement of the other channels. For a few miles near its mouth the channel of Left-Hand Chute (Little River) is larger and lies on lower ground and would carry more water than will be turned into it. It is not possible, however, to make economical use of this short section to its full capacity. Three cut-offs on this stream near Marked Tree have often been suggested, and it is popularly supposed that their construction would result in great benefit; but with the completion of the improvement herein planned the water surface in this section of the stream will be so nearly flat that these cut-offs will be entirely unnecessary.

The Right-Hand Chute of Little River must be made to carry the drainage of perhaps 75 square miles of land in Missouri which is too low to be drained into the floodway, and must be discharged underneath the levee on the State line through a conduit. The expense of constructing this conduit and all tributary works should fall upon landowners in Missouri whose property would be improved, but the work of this district should be planned so as not to make impossible the improvement of any land lying to the north. The Right-Hand Chute also must provide drainage for the territory between Pemiscot Bayou and the Big Lake reservoir. Much of this land lies very low, so that in order to drain it thoroughly the water in Right-Hand Chute must be carried very low in the ground. Because of the increased cost of carrying water low in the ground, drainage should be diverted into other channels wherever possible, leaving the burden of this stream as light as it can be made. The flood water level in some parts of the improved channel will be below the present bottom of the stream bed. From a point near the west quarter corner of sec. 11, T. 13, R. 8 the present channel of Right-Hand Chute will be abandoned. A channel will be constructed west for 4 miles to the lower ground alongside the Little River floodway, and thence along that and the St. Francis reservoir to the St. Francis River. The required yardage for this improvement will be considerably less than if the channel of Right-Hand Chute were followed to its outlet into the St. Francis River; the cost per yard of excavation should be less for cutting a new channel than for clearing the old one, while the cost of maintenance would be far less on the new channel. The excavation, instead of forming useless waste banks along the river edge, would greatly increase the strength of the dike along the floodway and reservoir. The old channel of Right-Hand Chute will be left to carry the drainage of the territory between it and the Left-Hand Chute (Little River). About 7 miles north and 2 miles east of Marked Tree it becomes too small even to carry this quantity of water, and another and smaller cut-off is made to the floodway three-quarters of a mile to the west.

No improvement for the purposes of this district of the St. Francis River below Marked Tree, or of the Tyronza below a point near the south line of Poinsett County, will be necessary.

The improvement of the Lower St. Francis River below the outlet of Big Bay in Cross County is not considered. The only parts of the proposed district which would be affected are a small area near the intersection of Big Bay with the south line of Poinsett County and the lower extremity of the bed of St. Francis Lake; and the completed plan will probably include provision for the thorough drainage of these areas.

DISTRIBUTION OF WATER BETWEEN THE CHANNELS.

The ditch on the east side of the St. Francis floodway will extend southwesterly along the floodway to its terminus in Cross County, but a considerable part of the water carried in its upper course will be diverted into the St. Francis River at its intersection with the bed of that stream. The discharge will be divided between these two channels, each carrying its proportion of the flow. Likewise a cut-off from the Tyronza River to the St. Francis, about 2 miles south of Marked Tree, will allow water to pass from one of these streams to the other, depending on which is higher. It is improbable that extreme high water will occur in all three of these channels at exactly the same time, and the cut-offs will allow each to relieve the others in time of greatest need. Moreover, the comparative amount of run-off from the different areas can not be definitely calculated on account of differences of soil and topography, and will change from year to year as timber cutting and clearing progress. These cut-offs will serve to adjust any variations from the actual run-off which may have been made in calculating the capacities and duties of the channels. Dillard's cut-off, near La Panto, will in its present condition serve to adjust the flow between the two chutes of Little River.

THE SYSTEM OF LATERAL DITCHES.

A study of the situation has led to the conclusion that for the most part lateral ditches should be placed about 1 mile apart in order that complete drainage may be secured. Very little thorough drainage has been done in this part of Arkansas, but just to the north, in the St. Francis and Little River valleys in Missouri, drainage methods and practice in treating similar soil under similar conditions have reached a point where some definite opinions are held. In that locality it is found that ditches 2 miles apart do not thoroughly drain flat low-lying land, and the opinion is now generally held that lateral dredge ditches should be placed at intervals of about 1 mile.

In this flat wooded region there seems to be no machine which can compete with the floating steam dredge in cheapness of excavation for small channels, and so uniform and favorable are the conditions for work that there are few localities where dredging can be done more cheaply. The size and shape of the smaller lateral drains were not planned by ascertaining the greatest amount of water which must be carried by them, but rather by the size and shape of dredge ditches which can be constructed at the lowest cost per mile. The light quick-running dredges adapted to the prairie regions farther north are not suitable for this wooded locality, where a machine must be so strongly built that all but the largest stumps may be rooted out without danger of breakage. A dredge suitable for this work should be very substantially built, and probably will have a 1½-yard dipper and be mounted on a boat 18 or 20 feet wide. A very economical ditch for it to dig is about 22 feet wide at the top, 12 at the bottom, and 7 feet deep. These dimensions are planned for the smaller lateral ditches in the belief that in those circumstances where the same dredge must be used for digging the smaller parts of a ditch at the upper end and the larger part at the lower end, and where, on account of the size of the job a considerable number of dredges of a uniform type will be desired by contractors, a ditch of this size can be dug as cheaply as any smaller dredge ditch.

In some parts of the district, especially along the east and west margins, surveys were not made in sufficient detail to permit the exact location of lateral ditches shown upon the map. Locations are made approximately to indicate the general plan of detail drains, and as a basis for an estimate of cost.

DRAINAGE BY COUNTIES.

MISSISSIPPI COUNTY.

The northeast part of Mississippi County should be drained toward the west into the floodway, as is indicated on the map. A large saving in cost can be effected by this method. The remaining area east of Pemiscot Bayou and the Left-Hand Chute of Little River will drain into the Tyronza River through a system of parallel ditches, and that river will be enlarged to receive the water. Nearly all existing ditches will be used to good advantage except the one in the supposed bed of Tyronza Lake and the cut-offs on Pemiscot Bayou. The former will have to be enlarged to carry even the small amount of water which will come to it, and the latter will have about the efficiency of a minimum lateral ditch. As the surface of the eastern part of Mississippi County is irregular, it is probable that more detailed surveys will result in making possible more desirable locations in some instances. A small area along Pemiscot Bayou and the Left-Hand Chute of Little River is drained into that stream, while the remaining part of Mississippi County east of Big Lake will be drained into the Right-Hand Chute. This area includes most of the bed of Big Lake, which, though very low, will be thoroughly drained. The method of drainage of the remainder of the county is indicated on the map. (Fig. 2, p. 10.)

CRAIGHEAD COUNTY.

The great difficulty of drainage in Craighead and Poinsett counties is the disposal of the run-off from Crowleys Ridge, which may be found to cost more than the control of the St. Francis River. The soil of the ridge is very close and sheds nearly all of the water which falls upon it, while the steeper slopes allow the water to flow quickly over the surface and to collect more rapidly in the lowlands. In all probability the flood run-off per square mile from this ridge will be three times as great as that from the soils between the St. Francis and Little rivers. Examinations made after heavy rains warrant this conclusion, and the ditch system is planned on that basis. A large economy will be made by diverting a considerable part of this water into the floodway, and the cost will be further reduced by constructing ditches along the side of the slope in a southerly direction, enabling a much greater fall to be secured than through the bottom lands of the east. This method will also cut off the hillside drainage water from the base of the ridge and prevent much hillside washing and the silting up of the outlet ditches which otherwise would follow the clearing of this land. A more detailed survey will be required to make exact locations of these collecting ditches. These ditches and all others in this territory will discharge into the large ditch outside the St. Francis floodway.

To the east of St. Francis Lake a ditch along the north line of Craighead County will divert water from Missouri into the St. Francis floodway. The waste bank deposited on the south side of the ditch will form a levee, preventing overflow of Missouri water into the district. All the drainage water of the eastern part of the county will be discharged into the ditches outside the two floodways. At the point where the Little River floodway discharges into the St. Francis floodway the ditches along the outside of these and between them must also be discharged into the St. Francis floodway. This will be accomplished by building a secondary levee outside the ditches for several miles above their outlets to prevent their overflow upon adjacent land and allowing them to discharge at the water level of the floodway. A small area above the junction of the floodways, too low to be drained in this manner, must be drained underneath the Little River floodway by means of a culvert. The preliminary map (fig. 2, p. 10) is made on too small a scale to indicate this construction.

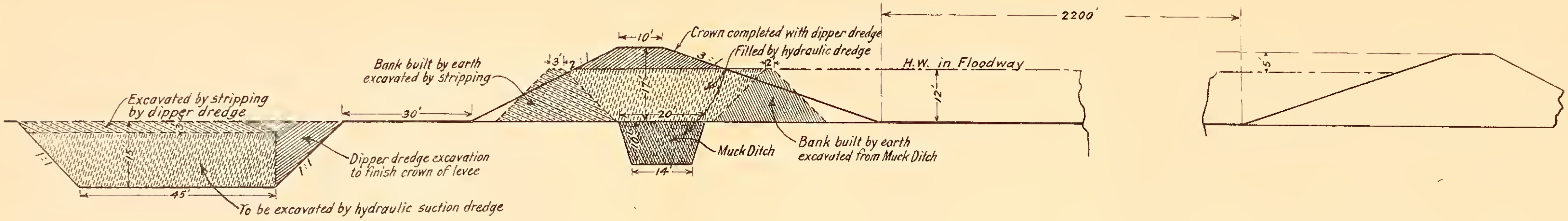
POINSETT COUNTY.

That part of Poinsett County west of the St. Francis floodway will be drained in a manner similar to that described for Craighead County, the great difficulty being in caring for the heavy run-off of Crowleys Ridge. As none of this can be deflected into the floodway, all must be carried in open ditches. A system of collecting ditches as indicated on the map will lessen the cost of carrying this ridge water. These collecting ditches will not be laid out on straight lines, as outlined on the map, but, like the similar ditches in Craighead County, must be so located as to have the desired fall along the slope of Crowleys Ridge. The location of all other ditches in this section is indicated on the map. Between the St. Francis River and the lower floodway most of the drainage will be west into the ditch along the floodway. Drainage district No. 1 of Poinsett County will provide local drainage for a territory northeast of Marked Tree. It is desirable that the lower extremity of this ditch be enlarged to the size required of a cut-off from Tyronza River to the St. Francis. The Right and Left Hand chutes of Little River in Poinsett County for the most part lie so high as to serve for little more than local drainage channels. The Left-Hand Chute (Little River) is much larger and deeper for a few miles above its mouth, but there is then no opportunity for economically diverting much water into it. The remainder of the local drainage is indicated on the map.

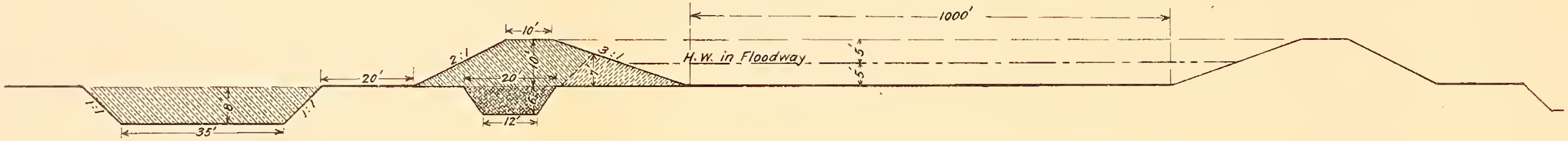
CROSS AND CRITTENDEN COUNTIES.

No lateral ditches, with the possible exception of one hillside ditch along Crowleys Ridge, will be constructed in these counties, and no improvement of the Tyronza or St. Francis rivers in these counties will be required. The St. Francis floodway will extend southward in Cross County along Big Bay to a point where that stream is enlarged to a cross section of 10,000 square feet near its mouth, and is of sufficient size to carry all water which may be delivered to it. While no ditch construction is contemplated in these counties, they will be very largely benefited by the prevention of overflows of Tyronza and St. Francis river waters from Poinsett County.

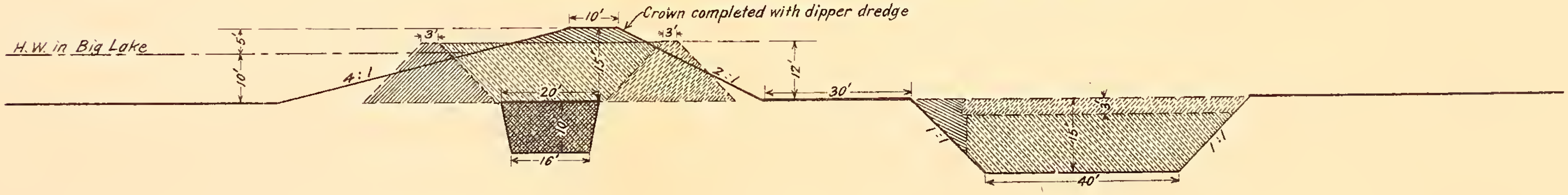
Section of St. Francis Lake Floodway

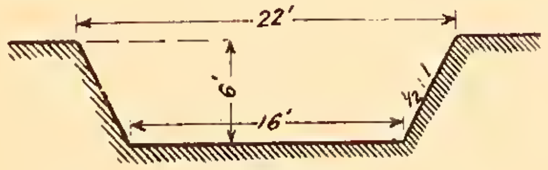

2200'
10'
Crown completed with dipper dredge
Filled by hydraulic dredge
3'
2
3
2
H.W. in Floodway
Bank built by earth excavated by stripping
Excavated by stripping by dipper dredge
30'
17'
12'
5'
20
3
15
1:1
1:1
10
Muck Ditch
Bank built by earth excavated from Muck Ditch
Dipper dredge excavation to finish crown of levee
14'
45'
To be excavated by hydraulic suction dredge

Section of Big Lake Floodway



Section of Levee on east side of Big Lake Reservoir; also for short section of lower end of St. Francis Lake Reservoir.





SECTION
Minimum Dredge Ditch
for Lateral Drain.

THE NORRIS PETERS CO., WASHINGTON, D. C.

Fig. 3.—Typical Cross-sections of Floodways and Ditches, St. Francis Project, Arkansas.

METHODS OF CONSTRUCTION AND ESTIMATES OF COST.

In determining the dimensions of channels and embankments the first consideration has been efficiency. It is believed that every construction recommended is of ample size and will fulfill every requirement of strength, capacity, and durability. In the second place, an effort has been made to plan the work so that it can be constructed by machinery known to work under similar conditions with speed and economy. It is believed that practically every construction is well within the limit of economical operation of the machine by which it probably will be built. It is also believed that seldom if ever in the history of reclamation work in this country has a more desirable piece of work from the contractor's point of view been in prospect.

Included as a part of this preliminary report is a sheet indicating the cross sections of the proposed ditches and levees, with suggestions as to their method of construction. (Fig. 3.)

COST OF LAND FOR RIGHT OF WAY.

The cost of all land necessary for right of way on the entire work, except the land within Government meander lines in the St. Francis and Big Lake reservoirs, is estimated at $20 an acre. This is considered a very liberal estimate, especially as much of the land which will be occupied by the floodways and by many of the ditches is the lowest and most nearly worthless in the district. The custom has not prevailed heretofore in northern Arkansas of paying for land taken up by ditches, but such payment seems to be the only equitable and just course to pursue.

RESERVOIRS AND FLOODWAYS.

No clearing of the ground will be necessary in either reservoir, and in the Upper St. Francis Lake the saving effected by a wide floodway, which will have sufficient capacity without being cleared, will go far toward offsetting the value of the additional land which would be redeemed by making the floodway half as wide. Any additional advantage apparently remaining in favor of the narrow floodway disappears when we consider the additional cost of building levees on the lower ground and the increased cost of drainage which would result from placing the main drainage ditches in the bottom of this depression where the surface slopes would be less. The plans for the remaining floodways include provision for clearing the ground of brush and trees, the stumps to be cut not more than 1 foot above the ground. The cost of clearing the floodway in this manner is estimated at $20 an acre, in addition to the value of the timber removed. In some instances the timber ought nearly to pay for clearing the right of way. The land included in the estimate for clearing the floodways includes that occupied by the floodways, the levees, and the ditches parallel to and outside of the levees.

CONSTRUCTION OF LEVEES.

It is believed that almost the entire work of constructing the levees can be performed under very favorable conditions for dredges. Down the center line of the floodway and reservoir levees a small dredge will construct a muck ditch, for the most part of the minimum size which can be made with economy. This in general will be 16 feet wide on the bottom, 22 feet wide on top, and about 6 feet deep. Being a much larger and a deeper muck ditch than is usually used in levee construction, it will furnish a sufficient bond between the fill and the ground surface, and the usual grubbing of stumps from the remainder of the levee base will not be necessary. The earth excavated for the muck ditch will be deposited to form the inner toe of the levee. Where the cross section is 500 square feet or less, the remainder of the levee will be constructed by a dredge, which will excavate earth from the ditch outside the levee. Where there is a cross section in excess of about 500 square feet, a hydraulic suction dredge will be found economical for making a part of the excavation. The accompanying sketch indicates the proposed method of construction. (Fig. 3.) A dipper dredge will strip the top 3 feet from the ditch section, building with the excavated earth the outside toe of the levee. The hydraulic dredge will follow, filling the section between the two walls built by this and the muck ditch. The finest earth will flow into the muck ditch, thus filling it with the best possible material to prevent seepage. Another dipper dredge following the hydraulic dredge will finish the crown of the levee. Each machine will do that work for which it is especially fitted, and each will have a sufficient cross section of excavation to make economical work. It is the opinion of men with wide experience in excavating with hydraulic dredges that there could scarcely be more favorable conditions for such construction than here outlined, and that the actual cost of excavation by this method under these conditions should not greatly exceed 3 cents a yard.

The work, like all other excavation considered in this report, is estimated at 8 cents a yard. Some of the dipper-dredge excavation on the levees will approach the limit for economical work with large dredges, but, it is believed, will not exceed that limit. The waste bank from a large drainage channel alongside the St. Francis levee will result in making that levee for more than half its length larger and more substantial than otherwise would be thought necessary and will increase the amount of excavation suitable for the hydraulic suction dredge.

It is probable, also, that in the clearing of the Tyronza River and the Right-Hand Chute of Little River the suction dredge can be used to advantage. The cost of excavating in the river channels is estimated also at 8 cents per yard. The actual cost would probably be somewhat greater than in excavating a new channel.

LATERAL DITCHES.

The lateral ditches will vary from a large channel, 70 feet wide on the bottom and 15 feet deep, where Big Bay discharges into the floodway ditch, to the minimum sized dredge ditches 16 feet wide on the bottom, 22 feet wide on top, and 6 feet deep. All of the excavation for these ditches is estimated at 8 cents per yard.

Investigations have been made to determine the actual cost of well-constructed dredge work in the wooded lands of the Mississippi Valley and of the South Atlantic Coast States. As a result of this investigation the opinion is held that under the uniform and favorable conditions obtaining in the St. Francis Valley and with well-equipped and well-managed modern dredges the cost of excavation to the contractor, including all cost of maintenance and repairs, should not exceed 4 cents per yard for the earth actually excavated, including the clearing of right of way.

In the proposed district there is no underground timber, as is encountered in the extreme South, and the soil presents almost uniformly favorable conditions for excavation. The ditches are so planned that dredges will be required to excavate almost no earth outside the section of the ditch as it is planned, and so would be paid for all earth excavated. On work of this nature a contractor should be allowed a considerable margin of profit, but it is believed that this would be secured at the estimated cost of 8 cents per yard. In the largest of these ditches hydraulic dredge excavation would be practicable, as in the ditches along the floodway, thus eliminating the necessity of performing with dipper dredges that excavation which is beyond the limit of the most economical work with these machines.

A table is appended to this statement giving a summary of the estimated cost of the entire work. This estimate will be revised in the completed report.

DETERMINATION OF THE SIZES OF CHANNELS.

Only a brief mention can be made at this time of the investigations undertaken to determine the amount of water which will be carried by the channels of the district in time of flood flow. The St. Francis drainage area in Missouri includes more than a thousand square miles of mountainous and hilly country from which the storm run-off is very rapid. An examination was made of this watershed for almost its entire length, and the topography was compared with that of numerous other mountainous watersheds where somewhat similar conditions prevail and where the flood discharges have been more or less carefully measured. A discharge of 50 cubic feet per second per square mile, or of about 2 inches of water from the entire watershed in twenty-four hours, was accepted as a safe factor of run-off. This is not as large a run-off as would occur on the upper watershed of the White River, in Arkansas, or of some other streams in the Ozarks, but it is believed that the factor is a safe one for the watershed under consideration.

The discharge from the low, flat alluvial lands of the district has been calculated by the formula—

$$C=\frac{24}{\sqrt{M}}+6$$

in which C = the run-off in cubic feet per second per square mile; M = drainage area in square miles. For drainage areas of 100 square miles this formula would give a discharge of about $8\frac{1}{2}$ cubic feet per second per square mile, or about five-sixteenths of an inch, run-off from the entire drainage area in twenty-four hours.

For the more rolling and less sandy land in the east part of Mississippi County the estimated run-off was increased 50 per cent. For the clay soils east of Crowleys Ridge the quantities obtained by the use of the formula were doubled in making estimates, and for the slopes of Crowleys Ridge three times the quantities determined by the formula were taken as the probable flood run-off. The soil of Crowleys Ridge will absorb very little water, and the steeper surface slopes will induce a very rapid flow of the surface water. It is probable that the storm run-off per square mile will be more than three times as great on Crowleys Ridge as on the flat land between St. Francis Lake and Big Lake, but by depositing the waste banks of the collecting ditches on the downstream sides of the ditches overflows may be prevented, even should the ditches run more than full for short periods. In all other instances the ditches of the district are planned of sufficient size to carry within their banks all the run-off of extreme rainfalls and are expected to complete the drainage of the territory, except for the construction of small tributary drains by individual landowners or the laying of tile where this may be found desirable.

SPECIAL PROBLEMS.

TRANSPORTATION.

To plan a great system of drainage in the Mississippi Valley without considering the possible development of transportation would be a very serious error, yet there are difficulties in the way of meeting both requirements, as they tend to be mutually exclusive. The object of a drainage channel is to carry off the surplus water as quickly as possible; that of a transportation channel to maintain a permanent great depth and low velocity. The locks which are necessary in most transportation channels to control the water level and limit the flow may be very undesirable where drainage is the chief consideration.

Inland water transportation in this country still remains to be developed. It might occur, after a large amount of money had been invested in the extra expense of making a drainage system suitable for transportation, that the district would have to wait ten or twenty years for transportation sufficient to pay the interest on this extra expenditure; developments of other methods of transportation during the coming years may forever put an end to the extensive carriage of freight by inland waters; or water transportation may itself develop requirements for different shapes and sizes of canals than would be built to-day. Against these difficulties stands the opinion, held as a conviction by engineers and men of forethought in our country, that our nation must with jealous care save its possibilities for inland waterways.

The drainage system here proposed has the great advantage of securing the most economical reclamation of this territory, and, at the same time, of saving to the future every possibility for the development of transportation channels. For while a deep channel, carrying the waters of the St. Francis and Little rivers below ground surface, if such were practicable, would go far toward destroying the possibility of ever securing in these channels the requirements of transportation canals, yet the system of floodways recommended will leave possible and will, in fact, invite such development. Within these floodways transportation channels may be built, including such locks as may be necessary, without injuriously affecting the land outside the dikes. Located as these floodways are, with long, straight reaches of uniform width, with uniform ground slopes, 35 to 45 feet below the levees along the Mississippi, and with excellent facilities for storing the waters of their tributary rivers in the hills of the north, they are sure to invite attention as a feasible location through this section for an inland waterway from the Great Lakes to the Gulf. Such a channel would leave the Mississippi River at Cape Girardeau, extend down the Little River Valley to the State line, thence along the line of the floodway to its outlet, and down the St. Francis River to the Mississippi near Helena.

The channels along the outside of the floodways will carry nearly a uniform depth of water throughout their length, sufficient during a part of the year for carrying any boats which now travel on Little River, while the Tyronza River, with a uniform cross section, can be used for boating to a greater extent than at present.

THE CONSERVATION OF SOIL MOISTURE.

Correct drainage consists in removing from the soil its excess of moisture and in saving the remainder for the use of crops. In heavy clay soils in the Northern States this question is seldom considered, for there is little if any danger of making those soils too dry by artificial drainage. The lighter soils of the central part of this district, however, may become too dry if care is not used in the planning of a drainage system. Where the land is too wet, the landowner may consider the removal of water to be the only important consideration, but unless a more far-sighted view is taken a reduction of crops is bound to occur during the dry seasons. These facts have been considered in planning the system, and in some instances drainage will cost more than though only the removal of water had been taken into account.

RAILROAD CROSSINGS.

The crossings of the Jonesboro, Lake City and Eastern Railroad and of the Paragould and Memphis Railroad over the Big Lake floodway can be made without difficulty. The St. Francis floodway will pass through existing pile bridges of the St. Louis and San Francisco Railroad northwest of Marked Tree, and the only additional expense encountered will be in providing for the passage of the dredging machines through the bridges. The present bridge of the Jonesboro, Lake City and Eastern Railroad over the St. Francis Lake at Lake City will require new approaches, but otherwise will not be affected.

THE INCIDENTAL VALUE OF THE RESERVOIRS.

According to the reports of the U. S. Fish Commission, the value of the fish harvest in the waters of northeast Arkansas tributary to the St. Francis River has in some years amounted to about $200,000. The value of fish secured from the overflow waters of the lower Illinois River amounts to about $5 per acre per year for all the water area. This is stated as the value of the fish crop delivered on the banks, and is about half that of the product on the market. It is also stated that this income will probably be doubled in the future. Taking these facts into consideration, it is seen that the areas occupied by regulating reservoirs on this project will not be entirely unproductive.

The construction can be planned so that these reservoir beds during dry seasons will contain more water than at present under similar conditions, and the growth and increase of fish will be correspondingly favored. With the intelligent development of fisheries which is beginning to take place in this country it is probable that in the future these areas will have a very considerable value to the people of the vicinity. Moreover, with the limiting of these bodies of water to definite areas, surrounded by well-drained land, their value as locations for pleasure resorts will increase, and a means of revenue which is not to be ignored will be added to this community. When we consider the extremely low character of these lake beds and the great expense necessary to their drainage, it is seen that their possible value may be greater for the purposes to which they are assigned than for agriculture. The construction work can be arranged so as to allow all timber within the reservoir limits to be removed.

THE DIVERSION OF THE ST. FRANCIS AND LITTLE RIVERS.

The points of diversion of these streams are within the beds of St. Francis Lake and Big Lake, where the river channels are narrow and shallow and where the surrounding surface is low, gradually sloping upward to the margins of the lakes. In each case it is planned to extend the levee from one side of the lake, building it almost to its full height as it is constructed, gradually crowding the small stream flow of low-water season to one side of the lake bed and thence into the floodway. By this method no difficult closures will be necessary, such as would be encountered if crossings of the streams were attempted where the channels are large and well defined, and the cost, in addition to that of building the levees, will be small.

THE NECESSITY FOR A SINGLE LARGE DRAINAGE DISTRICT IN THE ST. FRANCIS VALLEY.

There is an example in Europe of the difference in results secured through intelligent system in drainage work and haphazard, unrelated effort, which should serve as an example to the people of the St. Francis Valley. The fen lands of England and the submerged coast lands of Holland in the vicinity of Haarlem Lake lie nearly opposite each other across the English Channel. In England individual holdings and districts containing from a few hundred to several thousand acres were improved independently of each other, as though they had no common interests. As a continually larger part of the land was improved, the work of the several projects came in conflict more and more, and work of earlier districts was made useless by later improvements. Up to the present time an unknown amount, probably much in excess of $100 an acre, and more than the present value of the land, has been spent in drainage, and the conditions are still in some instances unsatisfactory.

In Holland a more difficult engineering problem was presented, because the land to be drained lay about 15 feet below sea level. This very difficulty made it impossible for small owners to work independently, and a plan was prepared for the drainage of the tract as a whole. The result is that this land, from which 15 feet of sea water had to be removed by pumping after the construction was completed, and from which drainage water must all be removed by the same method, was thoroughly and effectively reclaimed, and was sold at a handsome profit over the cost of the improvement.

The necessity for systematic drainage is not less urgent in the St. Francis Valley than in England and Holland, although the evil results of haphazard work may not for a time be fully apparent. The fact that a given ditch for the time being gives some relief to a locality may be no indication that it is properly laid out and constructed. A ditch may lower the flood height to some extent and result in the flood waters being carried away sooner, and yet have only a small fraction of the capacity required for thorough drainage; or it may for the time being drain the land directly tributary to it and later be made almost wholly useless by the construction of the ditches above it; or by being badly laid out it may greatly increase the cost of drainage below.

EXISTING DITCHES.

In preparing the present plans an effort was made to use the existing drainage ditches wherever practicable, and in some instances this can be done to good advantage. District No. 1 of Poinsett County, northeast of Marked Tree, becomes a natural part of the district as planned, and there will be no conflict between the working of this ditch and that of the larger district in which it is included. The plans for district No. 8 and the ditches already constructed in the southeastern part of Mississippi County have not been examined with care as to their efficiency, but on the whole they seem not to interfere with the main system of drainage. As the upper end of Tyronza River is wholly unequal to the demands to be put upon it, it will be desirable to divert the water of the main ditch, No. 8, at a point a short distance above its outlet, to a point farther down on Tyronza River where the capacity of that river is greater. The necessity for this diversion was recognized by the engineer of this district, and is indicated on the accompanying maps.

The ditches constructed and planned between Crowleys Ridge and the St. Francis River in Craighead and Poinsett counties will be of small service to the proposed district, and the construction of more ditches in this locality without reference to a general plan would be unfortunate for several reasons.

The plans in Craighead County up to the present time have contemplated carrying all of this water parallel to the St. Francis Lake and below the ground surface. The cost of this method over the one proposed in this report—that of diverting as much water as possible into the St. Francis floodway—would be not less than about $200,000, a loss with no compensating benefits. In the second place the plans heretofore have provided for allowing all the water from Crowleys Ridge to flow directly east into the bottom lands, and for carrying it in ditches along the bottom lands where the fall is much less. By laying out ditches along the side of the ridge to collect the water as it flows east, overflow of the land along the east base of the ridge would be prevented, and the ditches could be given so much greater fall that the same water could be carried at approximately half the cost. The locations of these collecting ditches given on the map are only approximate, and must be adapted to the surface slopes by a more detailed survey. The ditches laid out in this vicinity in the past are so entirely inadequate for thorough drainage that even if properly located they would have but little effect on the situation.

The dredge work done on the two chutes of Little River will be of little or no value toward thorough drainage, for the bottoms of most of these ditches are higher than the water surface must be in the completed channels if the low-lying lands are to be drained.

It is to be regretted that the cut-off from Tyronza River to Big Creek by way of Dead Timber Lake, now under construction, will be useless for carrying water from Tyronza River, for in order to make this river efficient for the drainage of territory lying to the north, its high-water surface at the outlet of Dead Timber Lake, 4 miles from the main cut-off on this ditch, must be 4 feet lower than the high-water line considered in the plans for the Dead Timber Lake ditch, or only 2 feet above the bottom of this ditch. It is probable, therefore, that the water of Dead Timber Lake in the 4 miles between the Tyronza River and this cut-off will flow toward the river and away from the cut-off. This piece of work, which seems to have been wisely and efficiently engineered from the standpoint of local drainage, indicates the impossibility of economically reclaiming this section of the country by piecework. If this ditch should be dug with the same yardage, but with a narrower bottom and 5 feet deeper than planned, it would be useful for the drainage of the Dead Timber Lake watershed.

Perhaps the most unfortunate move which could be made in the way of piecework in drainage would be the construction of the proposed ditch down Big Bay in Poinsett County. This ditch as planned, with a 30-foot bottom and carrying about 6 feet of water, would remove less than one-tenth of the flow of rainy seasons which would reach it from Craighead and Poinsett counties, to say nothing of the immense volume of water which overflows into Big Bay from the St. Francis River. The cost of this ditch would be largely a loss, and, moreover, it would increase the cost of future dredge work and make more expensive the final improvement of the region.

CONCLUSION.

A few general surface elevations are placed on the map as follows: At the upper ends of the St. Francis Lake and Big Lake, at the lower end of St. Francis Lake, at the outlet of the St. Francis floodway, and along the north line of township 12 across the district. These elevations are above sea level, Memphis datum.

With commendable energy and perseverance the landowners and engineers of this district have worked for the improvement of the region under conditions which made the most intelligent efforts at best but partially successful. But for the interest aroused and maintained in this way the more extensive investigation recently made would not have been possible. Local engineers have given every facility and every courtesy within their means for the completion of the survey on which the completed report will be based.

It is believed that by following this plan, which will be developed more fully in the completed report, the systematic and orderly reclamation of this district will be possible, making it one of the best examples in this country of the successful drainage of a large area at a moderate cost. It remains with the people of this district to determine whether this shall be done, or whether, by conflicting and unrelated efforts at detail drainage, the cost of the work will be very greatly increased, the desired results only partially secured, the drainage of the territory as a whole indefinitely delayed, and perhaps a large part of the lower land rendered finally impossible of drainage.

APPENDIX NO. 1.

Elevations and dimensions indicating some general features of the proposed drainage system. Elevation above sea level, Memphis datum.

(1) St. Francis reservoir and floodway:

(*a*) Between Green and Craighead counties, Ark.—

	Feet.
General bottom elevation in floodway	239.0
Flood-water surface in floodway	245.75
Elevation of top of levee	251.0

(*b*) At entrance of Little River floodway—

General bottom elevation in reservoir	225.0
Flood-water surface in reservoir	232.5
Usual water surface (about)	228.0
Elevation of top of levee	237.5

(*c*) At lower end of reservoir—

General bottom elevation in reservoir	218.0
Flood-water surface in reservoir	231.0
Usual water surface in reservoir (about)	222.0
Elevation of top of levee	236.0

(2) Big Lake reservoir:

(*a*) At State line—

General bottom elevation in reservoir	243.0
Flood-water surface in reservoir	247.0
Usual water surface in reservoir (about)	245.0
Elevation of top of levee	252.0
General elevation of lake bed east of reservoir	243.0

(*b*) At upper end of floodway—

General bottom elevation in reservoir	238.0
Flood-water surface in reservoir	247.0
Usual water surface in reservoir	244.0
Elevation of top of levee	252.0
General elevation of lake bed east of reservoir	239.0

(3) St. Francis floodway:

Length of floodway, 24.7 miles.

Width between levees, 2,200 feet.

Depth of water at flood stage, 12 feet.

Surface slope of water, 4 inches to 1 mile.

Height of levees above flood-water level, 5 feet.

(*a*) At beginning of floodway—

General surface elevation	219.0
Flood-water surface	231.0
Elevation of top of levee	236.0

(*b*) At south line of Poinsett County—

General surface elevation	213.0
Flood-water surface	226.3
Elevation of top of levee	231.3

(*c*) At end of floodway—

General surface elevation	209.0
Elevation of top of levee	221.0

Cross section of channel of Big Bay, 10,000 square feet.

(4) Little River floodway:

Length of floodway, 20¾ miles.
Width between levees, 1,000 feet.
Depth of water at flood stage, 5 feet.
Surface slope of water, one-half foot to 1 mile.
Height of levees above flood water, 5 feet.

	Feet.
(*a*) At beginning of floodway—	
General surface elevation	242. 0
Flood-water surface	247. 0
Elevation of top of levee	252. 0
(*b*) At end of floodway—	
General surface elevation	229. 0
Flood-water surface	236. 6
Elevation of top of levee	241. 5

A few significant elevations are placed on the map.

APPENDIX NO. 2.

Estimate of cost.[a]

FLOODWAY AND RESERVOIR SYSTEM.

St. Francis floodway:		
Total length, 24.7 miles.		
Right of way, 7,904 acres, at $20 per acre	$158,080	
Clearing right of way, 7,904 acres, at $20 per acre	158,080	
Levees, 8,851,600 cubic yards, at 8 cents per yard	708,128	
Muck ditch, 49.4 miles, at $2,659.52 per mile (8 cents per yard)	131,380	
Passing through Frisco Railroad bridge	2,000	
Two highway bridges, at $13,200	26,400	
Wire-netting core protection against burrowing animals	25,000	
		$1,209,068
Little River floodway:		
Total length, 20.75 miles.		
Right of way, 3,413 acres, at $20 per acre	68,260	
Clearing right of way, 3,413 acres, at $20 per acre	68,260	
Levees, 3,952,910 cubic yards, at 8 cents per yard	316,232	
Muck ditch, 41.5 miles, at $1,501.86 per mile (8 cents per yard)	62,327	
One highway bridge	6,600	
Two railroad bridges, at $13,200	26,400	
One culvert (under outlet of floodway)	15,000	
		563,079
St. Francis reservoir and leveed lake bed:		
Total length, 35.7 miles.		
Total area within levees, 70 square miles.		
Right of way, surveyed land, 7,190 acres, at $20 per acre	143,800	
Clearing right of way for levees, 1,860 acres, at $20 per acre	37,200	
Levees, 4,687,650 yards, at 8 cents per yard	375,012	
Muck ditch, 61.4 miles, at $2,816 per mile (8 cents per yard)	172,902	
Railroad bridge adjustment at Lake City	5,000	
Highway bridge adjustment at Lake City	2,500	
Wire-netting core protection against burrowing animals	8,500	
		744,914
Big Lake Reservoir:		
Total length, 8.8 miles. Total area within levees, 16.45 square miles.		
Right of way, surveyed land, 105 acres, at $20 per acre	2,100	
Clearing right of way for levees, 535 acres, at $20 per acre	10,700	
Levees, 1,550,250 cubic yards, at 8 cents per yard	124,020	
Muck ditch, 8.8 miles, on west side, at $1,501.84 per mile	13,216	
Muck ditch, 8.9 miles, on east and south sides, at $2,816 per mile	25,062	
Wire-netting core protection against burrowing animals	5,000	
		180,098
Total cost of floodway and reservoir system		2,697,159

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[a] Since this estimate was prepared, further examinations of the cost of certain portions of the work indicate that $318,000 should be added to the estimate.

RIVER IMPROVEMENT.

Tyronza River:	
From near the north line of section 16, T. 11 N., R. 8 E., to the south line of Poinsett County.	
Total length, 20.25 miles.	
Excavation, 2,018,750 cubic yards, at 8 cents per yard	$161, 500
Improvement and diversion of Right-Hand Chute:	
Total length, 34.2 miles.	
Excavation, 3,789,991 cubic yards, at 8 cents per yard	303, 199
(Excavation for levee construction not included.)	
Total cost of river improvement	464, 699

DITCH SYSTEM.

System No. 1.—West of the St. Francis floodway and reservoir:		
Miles of ditch (not including 53 miles excavated along floodway), 260.2.		
Excavation (this includes cost of excavation along floodway not necessary for levee construction), 12,239,780 cubic yards, at 8 cents per yard	$979, 182	
Right of way, 3,150 acres, at $20 per acre	63, 000	
		$1, 042, 182
System No. 2.—North of Little River floodway (except drainage discharged through conduit):		
Miles of ditch (not including 43.8 miles excavated along floodway), 142.7.		
Excavation (this includes cost of excavation along floodway not necessary for levee construction), 4,655,800 cubic yards, at 8 cents per yard	372, 464	
Right of way, 1,730 acres, at $20 per acre	34, 600	
		407, 064
System No. 3.—Mississippi County drainage into Big Lake reservoir:		
Miles of ditch, 48.4.		
Excavation, 2,891,200 cubic yards, at 8 cents per yard	231, 296	
Right of way, 585 acres, at $20 per acre	11, 700	
		242, 996
System No. 4.—Between Tyronza drainage area and floodways:		
Miles of ditch (not including 70.8 miles of ditches excavated along floodway, or excavated by Right-Hand Chute diversion), 238.4.		
Excavation (this includes cost of excavation along floodway not necessary for levee construction), 5,230,200 cubic yards, at 8 cents per yard	418, 416	
Right of way (this estimate does not include drainage district No. 1, now under construction in Poinsett County), 2,885 acres, at $20 per acre	57, 700	
		476, 116
System No. 5.—Tyronza River drainage area:		
Miles of ditch, 250.1.		
Excavation, 8,100,300 cubic yards, at 8 cents per yard	648, 024	
Right of way (this estimate does not include drainage district No. 8, in Mississippi County), 3,030 acres, at $20 per acre	60, 600	
		708, 624
Total cost of ditch system		2, 876, 982

Total miles of ditch (not including 167.6 miles along floodway and in Right-Hand Chute diversion), 940.

SUMMARY.

Floodway and reservoir system	$2,697,159	
River improvement	464,699	
Ditch system	2,876,982	
		$6,038,840
Engineering, legal, and contingent expenses (about 8 per cent)		485,000
Total cost		6,523,840

	Acres.
Approximate area of district	1,040,000
The above includes district No. 1, of Poinsett County; district No. 8, of Mississippi County; land occupied by floodways and reservoirs; and land on the borders of the district not affected by this improvement, aggregating about	200,000
	840,000

Approximate average cost per acre, $7.77.

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